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**Achieving environmental sustainability through the implementation of innovative projects aimed at reducing greenhouse gas emissions, and other innovative initiatives**

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***Annotation.*** *The article analyzes modern innovative technologies that contribute to improving environmental sustainability. Methods for reducing greenhouse gas emissions are considered as the main approach. The aim is to analyze possible strategies for managing innovation in environmental projects aimed at reducing greenhouse gas emissions and developing zero-emission technologies. The research methodology includes a theoretical analysis of the main provisions of environmental sustainability, a method of analysis, a method of synthesis, deduction and generalization of results. The results of the study contain conclusions on trends in the development of environmental sustainability and methods for reducing greenhouse gas emissions, as well as recommendations for managing innovations in this area.*

***Keywords:*** *innovation management, environmental sustainability, greenhouse gases, zero emissions.*

**Introduction**

The relevance of the topic is conditioned by the fact that the issues of environmental sustainability at the global level are coming to the forefront. Governments of all countries have joined efforts to reduce negative environmental impacts associated with climate change. According to the study of scientists, many scientific reports and reports contain information about the volume of greenhouse gas emissions, the impact of transportation vehicles, the volume of industrial waste, which indicates that unsustainable socio-economic development leads to massive destruction of the environment.

The problematization of the study is based on the assertion that the natural environment is deteriorating for several reasons. First of all, due to carbon dioxide (CO2) emissions which leads to environmental pollution, over-consumption of natural resources. The rapid economic growth of recent decades has also led to a number of environmental problems [1, p. 90]. In the theoretical aspect, environmental sustainability is understood as the responsible and balanced use of natural resources to meet current needs without harming future generations. The ultimate positive outcome for environmental sustainability is to ensure long-term stability and longevity.

The aim of the article is to propose, based on the analysis of available methods of innovation project management, measures to improve environmental sustainability through the reduction of greenhouse gas emissions and the development of zero-emission technologies.

The scientific novelty of the work consists in the fact that on the basis of theoretical and methodological foundations for the study of environmental sustainability, ways to improve the management of innovation projects to reduce greenhouse gas emissions are proposed. The effectiveness of the application of techniques to innovation management has been evaluated.

**Objects and methods of research**

The object of the study is environmental sustainability in the context of innovation projects. The research methodology includes a theoretical review on environmental sustainability and innovation management. The analysis method identifies and identifies the most effective technologies to reduce greenhouse gas emissions, with the help of the review various strategically important sectors are considered. With the help of evaluation and synthesis methods, conclusions are drawn on the feasibility of the proposed measures to improve the management of innovation projects.

**Literature Review**

The theoretical underpinning of the concept of innovation management began to emerge in the last century. Since the early 1990s, industrial ecology has been described as an approach that seeks to improve the environmental performance of technological systems. However, the focus of this approach has often been on optimization.

Foreign and domestic researchers consider innovation in the context of its impact on social and economic progress. The increasing importance of innovation activity for environmental sustainability is emphasized by the studies of renowned scientists, including K. Christen, V. Abernathy, C. Clark and S.G. Falco. At the same time, the introduction and management of innovation requires an integrated approach that takes into account not only technological aspects, but also socio-economic factors. According to the authors, the approach contributes to a more effective use of innovation potential to achieve sustainable development and ensure competitive advantages in the international arena [12, p. 5].

A great contribution to the study of innovation management was made by Y. Schumpeter, D.F. Drucker, B. Twiss, V.G. Medynsky, L.S. Blyakhman, N.D. Kondratiev, I.N. Molchanov.

It is worth saying that the basis of innovation activity was laid by scientist J. Schumpeter. He believed that the main aspect of innovation management is the willingness of the innovator-entrepreneur to risks and the inevitability of change. Innovations are able to bring significant monopoly revenues to the innovator enterprise in case of successful implementation, they are also a driver of economic growth through integration into other sectors and enterprises [9, p. 102].

Among scientists it is also worth highlighting the contribution of researcher N.N. Molchanov. According to his understanding, innovation is not just the embodiment of the result of scientific efforts. It is much more than bringing a new product or technology to the market. According to the author, innovation has a deep ecological and social context. It implies a purposeful improvement of social activity through the introduction into practice of effective solutions obtained as a result of scientific research [5, p. 70].

To date, within the framework of improving environmental sustainability, the changes caused by dynamic innovation activities are mostly related to production processes, industry, energy, distribution, logistics, marketing and other areas [3, p. 281]. Therefore, enterprises will have to significantly revise their organizational structure, change functions or create new departments, and develop new innovation projects.

**Results and their discussion**

At the current stage of environmental sustainability development, technologies to reduce greenhouse gas emissions through the production of liquefied natural gas (LNG) have gained importance. The LNG market, due to changes in the external environment and global influencing factors, has undergone significant changes to become a dynamic and increasingly important component of a serious energy market.

For example, the US practice prioritizes innovation and its evaluation based on basic research through commercialization, basic research through commercialization, basic research through commercialization and development of monitoring, reporting and verification standard, basic research through commercialization and development of MRV standards, basic research through demonstration [12, p. 11]. In this context, among the main projects are the following:

* solar photovoltaic systems development; concentrating solar thermal power (CSP);
* system integration;
* in the field of production: electrolysis; natural gas with CCUS; advanced renewable pathways; other carbon-based feedstocks;
* application of point source carbon capture technologies such as carbon capture; carbon conversion; carbon transportation and storage;
* direct air capture (DAC) with storage;
* enhanced mineralization;
* biomass with carbon removal and storage;
* use of marine fuels that can be derived from by-products;
* life-cycle assessment and technical support in the development of green corridors;
* development and application of a viable plasma fusion reactor (magnetic, inertial and magneto-inertial approaches);
* use of modern low activation materials [12, p. 12];
* cost-effective alternatives for low- or zero-carbon process heating and the use of clean heat;
* in agriculture: measuring, monitoring and reducing methane emissions from livestock and crop production. Other sources: Measurement, monitoring and reduction of methane emissions from non-agricultural sources such as oil and gas systems, landfills and reservoirs [12, p. 13].

The development of new solutions and adaptation to the external environment plays a special role, especially in the current geopolitical conditions. The transition to clean energy sources and the growth of LNG transportation opportunities, as opposed to pipeline transportation of gas, have become important factors contributing to the development of the global gas market [4, p. 1024].

In order to reduce greenhouse gas emissions, LNG is being introduced as a marine fuel, which is backed by technological advancements. Technological innovations in LNG have also led to the emergence of new markets and applications. The ability to efficiently and safely transport LNG to different parts of the world has become a major focus. This diversification of the energy balance increases energy security and independence [2, p. 44].

Innovative projects and technologies are also being developed to reduce the carbon footprint of the atmosphere, based on competent and rational recycling of waste through proper disposal procedures. The transport sector is the main source of carbon dioxide emissions, primarily due to the fact that gasoline-powered cars and trucks are predominantly used in the world [6, p. 1]. In order to reduce the negative impact of transportation on the environment at the national, regional and federal levels, the implementation of stable, long-term policies that are ready to support the development of zero-emission transportation continues. This contributes to the gradual transition from traditional vehicles to environmentally friendly and safe vehicles.

At this point, the commercialization of hydrogen technology has already begun worldwide. It has been determined that even a partial introduction of hydrogen energy will entail major structural changes in the economy as a whole. The introduction of hydrogen energy in the automotive sector is primarily associated with well-developed traditional technologies based on the use of piston internal combustion engines (ICE) in vehicles [7, p. 553].

In the context of large-scale environmental development, several types of electric vehicles have emerged, which can be broadly divided into purely electric cars, hybrid cars, hydrogen fueled cars and natural gas vehicles. According to experts, the number of such modern environmentally friendly cars will reach the level of more than 13.1 million, which is about 13% of all vehicles.

It is worth saying that modern approaches in managing environmental innovations are Agile and Lean. Agile technology allows you to see transparency in project work and manage frequently changing priorities. The reason for this lies in the process itself, based on Scrum, Kanban or another agile approach. Such approaches involve both visualization of work and iterations, the results of which make it easier to change priorities than in an inflexible process. Agile technologies in the context of environmental sustainability enable industrial enterprises to achieve sustainable competitive advantage through a culture of high-performance teamwork, innovation, collaborative decision-making, learning and continuous improvement of processes and systems.

Lean (lean manufacturing) was conceived as a management system aimed at reducing waste in all forms in pursuit of continuous flow, operational efficiency and competitive advantage. Lean operates on the basis of five principles that aim to manage and minimize waste, which in turn protects the environment. Since its introduction, lean manufacturing has become an important model in the manufacturing industry as a successful process to enhance the competitiveness of organizations.

In terms of commercialization of environmental technologies, modern approaches imply that research and development centers, in collaboration with companies, apply the latest advances in science and technology, which are very important for the implementation of environmentally friendly production processes. Industrial companies, realizing the need to update and improve their technological solutions in order to minimize the harmful impact on nature, should actively show interest in acquiring and implementing innovative environmentally friendly technologies. The effective implementation of such projects and technologies in the production sphere plays an important role in improving the environmental condition in the country and is strategically important for achieving sustainable development. This situation reinforces the need for commercialization to turn scientific innovations into commercially successful products. Attention should therefore focus on establishing mutually beneficial collaborations between researchers who create innovations and entrepreneurs who seek to apply these advances to their businesses. On the way to solving such problems it is worth working both at the level of individual companies and at the national level, paying attention to the formation of an environmentally friendly and favorable business climate [8, p. 19].

The realization of environmental innovation projects allows to obtain four main effects:

* economic,
* scientific and technical,
* social,
* ecological.

As a result of selecting the most effective projects, it is advisable to calculate a comprehensive indicator of the effect from the implementation of environmental innovation project. Such a complex indicator is calculated as follows [10, p. 43]:

 , where

C – calculated commercialization indicator.

n – total number of criteria.

Wi – weight coefficient of the i-th factor, reflecting its importance for the commercialization of the project.

Fi – value of the i-th factor obtained as a result of the project analysis.

Kstem – a coefficient that adjusts the commercialization assessment to the specifics of the industry within STEM (science, technology, engineering, mathematics). This coefficient helps level the playing field for comparing projects from different sectors, taking into account their industry specificity and market potential. for environmental purposes can be chosen >1 (1.1-1.5) due to the relevance of the topic.

Another option for calculation may be the use of Fishburne's law:

, where

Ei – effects from realization of ecological innovation project (economic, scientific and technical, social, ecological),

i – weight coefficient of the corresponding effect. The selection results in a list of the most effective innovation projects for the n-th organization for the n-th period of time.

So, to improve innovation management in the field of ecology, it is worth revising the existing approaches, focusing on the integration of technologies and industries, agriculture, transportation and so on. Since the existing environmental problems need an integrated approach, which implies the integration of science, technology, engineering and education. At this stage, it is worth paying attention to the system of training and retraining of innovation project leaders and managers. Training programs should combine the basis of environmental sustainability and safety, as well as IT solutions and innovation management. Another recommended aspect is to strengthen the role of state support and stimulate private investment in environmental innovation. Such joint work of the state and entrepreneurship can significantly accelerate the implementation and scaling up of successful projects. Creating favorable conditions for investment, including through tax incentives, grant support and other incentives, is key to attracting financial resources to eco-innovation.

In addition, it is necessary to emphasize the introduction of digital technologies and big data in the management of environmental innovation. This will make it possible to analyze and forecast ecological processes. The application of artificial intelligence, machine learning, blockchain technologies and the Internet of Things will increase the efficiency of innovation management and improve environmental monitoring.

**Conclusion**

Thus, summarizing, we can conclude that innovation management in the field of environmental sustainability today is a particularly important issue that requires a comprehensive and integrative approach. This approach should be based on the combined efforts of the state, business and industry, agriculture, scientific and research centers, and educational institutions. At the moment, a number of technologies capable of reducing greenhouse gas emissions have already been introduced, and the transition to a more environmentally friendly mode of transportation and the use of solar energy is gradually taking place. Assessing the contribution of the research, we can conclude that it is necessary to form a holistic theoretical framework. Such a base is able to combine environmental, economic and social aspects of sustainability and serve as a basis for practical application of innovative projects.

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